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'Plugging the Gaps' Between Optimum Bias and Strategic Misrepresentation and Infrastructure Cost Overruns

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Abstract

Infrastructure projects regularly experience cost and schedule overruns. Research led by Flyvberg has suggested that misrepresentation and optimum bias are primary causes for overruns. While Flyvberg's research has made a significant contribution to ameliorating understanding as to why economic infrastructure projects experience overruns, it does not adequately explain why this is the case for such social infrastructure. In addressing this shortcoming, a case study is used to determine the intermediary events and actions that contributed to it experiencing a project cost overrun. The events and actions that contributed overruns are identified and analyzed. The analysis of the case study findings has led to the propagation of nomological framework for social infrastructure project overruns.

Keywords: Design errors, pathogens, overruns, social infrastructure

1. INTRODUCTION

High profile infrastructure projects that experience cost and time problems or contractual disputes attract media attention as the community contributes to funding their delivery. Several notable projects in recent times include Denver's US$5 billion airport that experienced a cost overrun of 200%, the DKK 800 million Øresund Bridge that experienced a 68% cost overrun, and the Scottish Parliament Building which was over 3 years late and experienced more than a 900% cost overrun. In Australia, several large scale social infrastructure projects (i.e., hospitals, law and order, museums, schools, recreational facilities), have experienced considerable delays due to poor project governance and design errors. More contemporary examples of this phenomenon include the Western Australian Perth Arena that had an original contract value of A$168 million but is now forecast to cost more than three times this amount, and be delivered at least three years later than expected. Flyvberg et al. (2005) has suggested that average

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cost overruns for infrastructure projects can range between 20.4% for roads, 33.8% for bridges and tunnels and 44.7% for rail. In contrast, Love et al. (2009a) reported significantly lower levels of average cost overrun, with roads 13%, and bridges 5.5%. This observed differential can be explained by the monetary value of projects. Flyvberg et al.'s (2005) research focused on mega-projects with contract values in excess of US$1 billion, whereas the contract values of Love et al.'s (2009a) work were considerably smaller with an average contract value of A$33 million. Credence should therefore be given to Flyvberg et al.'s (2004) assertion that a positive correlation exists between contract value and cost overrun.

According to Flyvberg et al. (2009) there are two rudimentary reasons why projects experience cost overruns. Firstly, strategic misrepresentation, which is an Orwellian euphemism for describing deceptive actions used by politicians and planners to ensure that projects proceed. Secondly, optimum bias, which encapsulates the systematic tendency for decision makers to be over-optimistic about the outcome of, planned actions (Flyvberg, 2008). This includes over-estimating the likelihood of positive events and under-estimating risk and loss. Despite comprehensive research that explains 'why' and 'how' infrastructure projects experience cost and schedule growths, this issue remains an unresolved problem for governments internationally. Irrespective of malignant practice or unsubstantiated optimism infrastructure projects continue to be subjected to significant levels of rework, which predominately arises through design changes and errors. While Flyvberg's research has made a significant contribution to ameliorating understanding as to why economic infrastructure projects experience overruns, it does not necessarily explain why this is the case for such social infrastructure. In addressing this shortcoming, a case study is used to determine the intermediary events and actions that contributed to cost overruns.

2. CAUSATION

The actions of strategic misrepresentation and optimum bias may stimulate *pathogens* to reside within the environment that infrastructure projects are procured. Pathogens are latent conditions and lay dormant within a system until an error comes to light. Before discovery, designers remain unaware of the impact that particular decisions (e.g., design re-use), practices (e.g., incomplete documentation) or procedures (e.g., limited design checks and reviews) can have upon project performance. Pathogens can arise due to strategic decisions taken by top management or key decision-makers. Latent conditions can reside within a system for a considerable period of time and become an integral part of everyday work practices. Once they combine with 'active failures' then errors can arise and the consequences of which may be significant. Active failures are unsafe acts committed by people who are embedded within a system. Such acts include: *slips*, *lapses*, *mistakes* and *non-compliance*. Active failures are often difficult to foresee and cannot be eliminated by simply reacting to the event that has occurred. Latent conditions however can be identified and remedied before an adverse event occurs. Pathogens can be defined by a number of qualities as they are (Busby and Hughes, 2004:p.428): (1) a relatively stable phenomena that exist for a substantial time before the error occurs; (2) not seen as obvious stages in an identifiable sequence failure before the error occurs; and (3) strongly connected to the error, and are identifiable as principal causes of the error once discovered. The pathogens that contribute to error occurrence can be categorized as (Busby and Hughes, 2004):

- Practice – arising from people's deliberate practices;
- Task – arising from the nature of the task being performed;
- Circumstance – arising from the situation or environment the project was operating in;
- Organisation – arising from organizational structure or operation;
- System – arising from an organizational system;
- Industry – arising from the structural property of the industry; and

- Tool – arising from the technical characteristic of the tool (e.g., software)

Many pathogen based errors in engineering firms are based on *practices* (i.e. those pathogens from people's deliberate practices) that attempted to solve a particular problem (Love *et al*., 2009a). For example, recycling design details, specifications, and other contract documentation to reduce time and save money without giving due considerations to the project's bespoke nature. Commencing work using tentative information is often a consequence of working with non-traditional procurement methods (where design and construction activities are overlapped) and therefore, short lead-times are often needed to meet a project's schedule. Individuals may repeat inappropriate practices, such as taking short cuts and not following due processes. When a practice provides an individual with a satisfactory outcome then this practice is used again on future projects irrespective of its suitability (Busby and Hughes, 2004). For example, the designer's decision to eschew audits, checks, verifications and reviews prior to releasing documentation for pricing or construction. Due to financial pressures being imposed upon design firms by their clients, this practice has become the norm (Love *et al*., 2009a). Lack of attention to quality management during the design process has resulted in the notion of rework becoming entrenched in work practices and consequently, less profit is being experienced by design firms. Love *et al*. (2008) suggests that design error induced rework may have settled within the industry at an insidiously comfortable level. If design consultants repeatedly produce design error-induced rework due to complacency, (i.e. the cost of doing business) then a chronic malaise becomes 'normal'. Whatever the percentage increase that is taken up by rework, that percentage will be added to the firm's costs. So, if rework accounts for 10% of regular work of a design firm (or any other type), this would lead to everything being increased by 10%: supervision, cycle time for administrative procedures, answering requests for information and so on. The time element translates into costs, which are then buried within 'normal' operating costs.

2.1. Counterfactual Causation

The relationship between strategic misrepresentation and optimum bias with cost overruns implicitly assumes causality in terms of counterfactual dependence of the effect on the cause: the cause is rendered counterfactually necessary for the effect. For instance, to say that strategic misrepresentation caused a cost overrun is to say if the misrepresentation had not occurred, then the cost overrun would not have ensued. To be more precise, causality can be defined by reference to a causal chain of counterfactually dependent events, where a sequence of events (C,E,F..) is a chain of counterfactual dependence if E counterfactually depends on C, E counterfactually depends on F and so on. Basically, Lewis (1973) asserted that "one event is a cause of another if and only if there exists a causal chain leading from the first to the second" (p.167). Various forms of counterfactual dependence have been adopted through the application of structural equations. Very limited studies in the literature have applied structural equations to examine the causal factors that contribute to the poor performance of infrastructure projects (e.g., Love et al. 2009). While such studies have provided a valuable contribution to understanding causal inferences through generalization, they have not provided a nomologically possible context. Such a context provides detail about how events unfold according to an underlying 'event theory', a set of background laws that define the outcome of events. Figure 1 illustrates three nomologically different contexts where strategic misrepresentation A and/or optimum bias C could give rise to a cost and/or time overrun E. Each node represents an event. In this instance the occurrence of event A or C or both (at some implicit point in time) is the cause of the occurrence of event E (at a later point in time).

In the context of (a), C and D are proximate (as are A and D), and C and E are remote. The occurrence of C stimulates D, in this case a design error, but inhibits B. The occurrence of D then results in E (i.e. a cost overrun). Besides, strategic misrepresentation and optimum bias, pathogenic influences can give rise to C and A, which then can trigger a series of events that result in E, a time or cost overrun (or both).

Determining the conditions that enabled events to occur would provide richer and more meaningful understanding of events that lead to design errors and time and cost overruns.

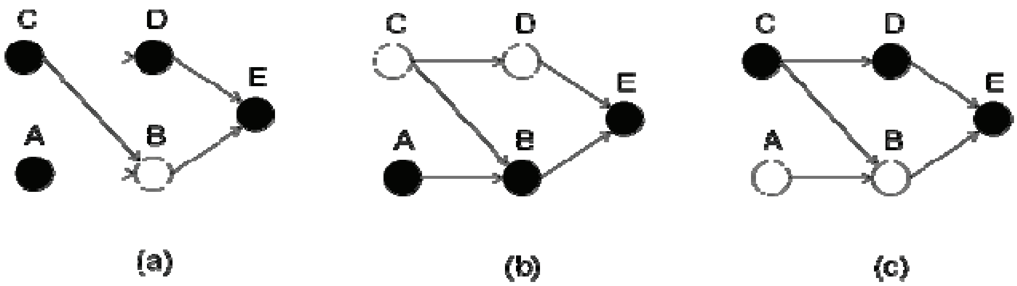

Figure 1. Nomologically different contexts each represent a different history

3. CASE STUDY

A case study approach based upon *analytic induction* is used to examine the underlying dynamics that may contribute to cost and time overruns in social infrastructure projects. A case study is exploratory in nature, based on interviews and relies heavily on verbal reports and unobtrusive observation as data sources. This methodology should be used to investigate the technical aspects of a contemporary phenomenon within a real life context, particularly in critical and unique circumstances (Flyvbjerg, 2006). It is particularly useful when the boundaries between phenomenon and context are difficult to ascertain and when multiple sources of evidence are used. A case study can provide analytical rather than pure statistical generalizations and can capture the complexity and dynamism of organizational settings in projects (Flyvbjerg, 2006).

3.1. Data collection

An Australian public sector client was invited (and subsequently accepted) to participate in the research during 2009. The client identified two projects where cost overruns were forecasted to occur due to significant design problems that were being experienced. Specifically, the problems pertained to design errors that occurred in the contract documents that were produced by the design consultants. With the unequivocal support and permission of the client, the researchers approached both design consultants and contractors involved with the identified projects and explained the nature of the research. All agreed to actively participate in the research. A series of in-depth interviews were conducted over a four month period with participants who had been involved with the delivery of a school. A total of 24 in-depth interviews were undertaken, which ranged between 60 to 90 minutes in duration with architect, engineers, project managers, contract administrators, contractor's project managers and client. The interviews were digitally recorded using a recording device, and then transcribed and distributed to each interviewee for comment and approval. Data collected during and after each project's completion enabled the researchers to develop a richer understanding of the key issues and errors that emerged during each project's procurement. A variety of methods were used to obtain data, which included interviews and documentary sources (e.g. variation lists, site instructions, architect's instructions, drawings and specifications, and non-conformances).

4. RESEACH FINDINGS

The school was procured using a traditional lump (TLS) sum contract and had a contract value of $25 million. The original contract period was 68 weeks and was delivered 17 weeks late. A cost overrun of $1.1 million due to design errors contained within the contract documentation occurred. Contracts for design services were procured using competitive tendering and the lowest tenders were awarded contracts. Likewise, the contractor was selected based on a competitive basis and thus the lowest tender. The State Government has a policy in place not to simply accept the lowest bid, but rather offer contracts on a Value for Money (VfM) basis. Therefore, it appeared that V*f*M was overlooked as a budget had been established for the school's development programme. The initial project estimates developed for the client overlooked the extent to which inflationary pressures had influenced material and labour costs within the local market. A dialogue between the researcher and client suggested that the client may have been slightly over *optimistic* or perhaps over confident with the initial estimate.

Issues surrounding accountability and probity appeared to be drivers for securing lowest price; there was little room to adjust the project budget. A culture of uncertainty avoidance within the client's organisation and critical decision-making processes appeared to reside. As will be demonstrated herein after, a combination of the lowest bids and a lack of project governance provided the stimulus for firms to adopt self-serving practices in an attempt to maximize their fees and profits. The design errors contained within the contract documentation that was produced provided a dysfunctional working environment where self preservation prevailed. A number of different types of pathogens emerged through the analysis and interpretations of findings. The most prominent pathogens identified related to *organisation, circumstance practice* and *task*. There was no evidence that any form of strategic misrepresentation arose during the interviews with the client, but a degree of optimum bias regarding the project's design and construction schedule prevailed.

The engineering design for the school was subjected to a number of multiple reviews, checks and sign-offs. While such policies and procedures are a vital part of the design process, they can also be detrimental and a waste of time if design consultants do not coordinate and integrate their work. In this case, a clear misunderstanding of expectations and requirements of the client and project team members occurred. It was revealed that the structural engineer and architect worked independently with limited design coordination and so consequently, design omissions, errors and changes occurred. Despite the occurrence of omissions and errors, the structural engineer was adamant that they had acted professionally and diligently. A focus on simply 'doing things right, rather than doing the right things' appeared to subconsciously reverberate from the structural engineer during the interview. The undertone from the structural engineer was that the engineering design was correct and that they were not responsible for errors that occurred. The engineer was however cognizant not to blame anyone, but implied that the architect failed to provide complete information when required. Recognizing the potential for errors in calculations and loading assumptions that could be made, the structural engineer organized for their work to be checked by a third party, specifically to ensure compliance to Australian standards. The structural engineer adopted a risk mitigation strategy to prevent errors from occurring. Risks were identified and prioritized and more time was then allocated to checking the critical designed components and structure. This process was deemed to be an essential part of the verification process; if it was not undertaken the potential for an engineering failure and accident was considered to significantly increase.

4.1. Design coordination

Audits, reviews and verifications are only useful if design documentation is coordinated systematically between design consultants. Despite the structural engineers' rigorous reviews, they omitted to design the storm water drainage. In fact, the architect, who was acting as the project's superintendent, overlooked this issue as well. As a result, the contractor did not include the storm water drainage in their tender submission and an independent hydraulics engineer was employed to attend to this oversight. Rectifying this omission error cost A$100,000. In another related example, the structural engineer omitted to 'design ferrule connections' which were required to be cast into the sixty precast reinforced concrete columns. Such connections would serve to accommodate the tensile forces imposed upon columns from the floor above. Again, this omission occurred due to inadequate information flow between the architect and engineer.

4.2. Motivation and incentive

The mechanical and electrical engineer suggested that a 'silo mentality' had become ingrained within the way in which projects were being procured. The engineers proceeded to state that there was no motivation or incentive in place to encourage design consultants to work together in a harmonious and collaborative manner to ensure documents had been coordinated and were complete. Fees were considered to be tight and with an unrealistic schedule in place to document the design, consultants implemented 'time boxing' (i.e. a fixed period of time may be allocated to complete each task, irrespective of whether the documentation or each individual task is complete or not) to ensure the key areas of the design were complete. In adopting this approach however they reduced their 'scope of work'. This resulted in aspects of their designs being incomplete which in turn led to inconsistencies occurring between architectural and engineering drawings as well contractual variations being raised and issued during construction.

5. TOWARD A NOMOLOGICAL FRAMEWORK

The association between strategic misrepresentation and optimum bias with project overruns which has been promulgated does not adequately explain why social infrastructure projects consistently under perform in terms of time and cost. The delimitation in Flyvberg and his colleagues' theorem is that intermediary conditions and events that lead to project overruns occurring are not examined or explained. A chronological lacuna exists between the initial event and final outcome. Only by understanding and knowing the causal of events occurring within a system can progress be made to ameliorating its performance. To assume overruns occur due to strategic misrepresentation or optimum bias, or a combination of both, disregards the complexities and underlying dynamics associated with the delivery of social infrastructure projects. Even when the aforementioned issues do not arise, the likelihood that a project would incur overruns is statistically high when factors such as structural and technical complexity, procurement arrangement, contractual conditions, managerial effectiveness, location, size and type of project are taken into account. An issue that compounds this quandary is the differing goals and objectives of the 'ephemeral coalition', which often can provide a forum for 'project dissonance'. Vehicles that can be used to reduce such dissonance and align goals and objectives are alliance based project structures. Such structures can provide movement toward consensus and reduce negative tensions that can prevail within projects. In addressing the shortcomings of Flyvberg's research, the events and actions that led to overruns in social infrastructure projects are identified and presented in a nomological framework in Figure 1. Retrospective analysis of events and actions that occurred has been useful for determining the pathogenic influences. In particular, the pathogens of *organization*, *circumstance*, *practice* and *task* were leitmotivs within the cases. Acknowledgment of these features translates into the following orthodoxy being produced:

> "The use of competitive tendering for selecting design consultants for social infrastructure projects establishes an environment where their services are reduced or omitted to maximize profit. The omission of critical tasks and practices such as design audits, reviews and verifications invariably leads to contract documentation being erroneously produced and therefore increases the propensity for cost and schedule overruns to be experienced".

The framework is intuitive and implies that competitive tendering stimulates design firms to adopt opportunistic and unethical behaviors. More often than not, when design firms are selected for a public sector project, overly competitive fees charged are deemed to be so low that there is minimal scope for profit. When these are combined with an overtly unrealistic expectation to design and prepare documentation, a breeding ground for practice and task related pathogens may begin to fester. In a quest to improve project performance, the public sector has entered a period of introspection. For example, there has been a proclivity to switch from conventional project delivery methods to PPPs, though the improvements gained have been marginal with many reported prominent failures; examples include the Port Macquarie Hospital in NSW State of Australia, the Sydney Airport Railway Link and the Sydney Cross City Tunnel. While significant efforts are being undertaken to develop innovative ways to reduce overruns, it would appear that an understanding as to why they occur has been, and continues to be, overlooked. A reason contributing to such an oversight pertains to a shortfall in knowledge causation and the interdependency that exists between events and actions.

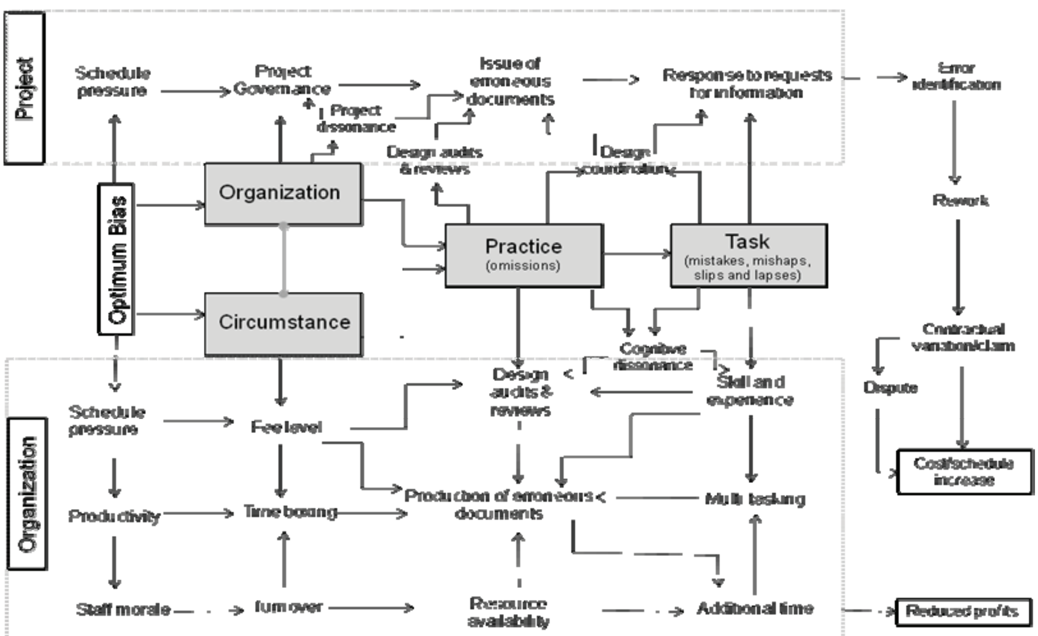

Figure 1. A nomological framework of design error and project overruns

6. CONCLUSION

Cost and schedule overruns have become an innate feature of infrastructure projects. Flyvberg and his colleagues' seminal work have suggested that strategic misrepresentation and optimum bias are the primary contributors to economic infrastructure overruns. A significant amount of projects however experience overruns without such actions being present. To simply assume that strategic misrepresentation and optimum bias are overarching actions that lead to the unsuccessful delivery of social infrastructure projects is misleading considering the complex array of conditions and variables that interact with one another during the a project's procurement. More importantly, solely focusing on addressing such actions may mask the underlying conditions that continually contribute to the adoption of opportunistic project and managerial practices. Understanding the conditions that result in design errors occurring is necessary to reduce their incidence within projects. An examination of a social infrastructure case presented in this paper revealed that errors contributed to a great deal of dissonance between project team members as well as increased project cost. An investigation as to why and how design errors occurred was undertaken. This resulted in the construction of a nomological framework and orthodoxy of design error and project overruns. In doing so, provides the impetus for governments to re-examine the ways in which they are delivering their social infrastructure projects. Unless there is a fundamental shift away from the use of competitive tendering to select design consultants and a mandate for design reviews, checks and verifications to be undertaken throughout each phase of the design process, then errors will remain and contribute to contribute to overruns in social infrastructure projects.

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